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# Development of a Unified Experiment-Based Exploration Sheet in General Physics 1 – Kinematics for Grade 12 Students of Surigao City National High School, Philippines

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**ABSTRACT:** This study aimed to develop and evaluate the effectiveness of a Unified Experiment-Based Exploration Sheet for Grade 12 General Physics 1, focusing on the topic of kinematics. Studies have consistently shown that students experience misconceptions regarding motion, velocity, and acceleration, often interpreting velocity as synonymous with acceleration and struggling to distinguish scalar and vector quantities. The study was conducted in response to the persistent low performance of Filipino students in science, as evidenced by the Philippines' below-average performance in the PISA 2022 assessment, and the continuing difficulty of students in understanding abstract physics concepts and problem-solving ability due to limited laboratory resources and traditional teaching approaches. Unlike existing inquiry-based activity sheets, the developed Unified Experiment-Based Exploration Sheet integrates standardized experimental procedures, locally available materials, and MELC-aligned inquiry activities into a single instructional resource designed specifically for Grade 12 Kinematics. Using a research and development design based on the 4D model (Define, Design, Develop, and Disseminate), the Exploration Sheet was developed and validated by four experts providing qualitative evaluation and feedback. Fifty (50) Grade 12 STEM students from Surigao City National High School using stratified random sampling participated in the implementation phase. A 40-item multiple-choice test on kinematics was administered as a pre-test and post-test to measure learning gains. Descriptive statistics and a paired-samples t-test were used for data analysis. Results revealed that students' mean pre-test score was 28.6 (SD = 5.37), which increased to a mean post-test score of 37.3 (SD = 4.64), yielding a mean gain score of 8.68 (SD = 6.61). The paired-samples t-test indicated a highly significant difference between pre-test and post-test scores ($p < .001$), confirming the effectiveness of the developed material. These findings suggest that the Unified Experiment-Based Exploration Sheet is an effective instructional material that can significantly improve students' understanding of kinematics through structured, inquiry-based, and context-appropriate learning activities.

**KEYWORDS:** Inquiry-based learning; science instructional materials; hands-on experimentation; physics education; educational material development

## 1. Introduction

General Physics 1 is one of the specialized subjects for students pursuing the Science, Technology, Engineering, and Mathematics (STEM) strand in Senior High School, providing them with foundational concepts and thinking skills necessary for STEM-related courses. However, Reyes et al. [1−3] highlighted the continuing difficulty in facilitating improved scientific achievement across all grade levels within the Philippine Basic Education System. In the Program for International Student Assessment (PISA) 2022 [1] Science assessment, the Philippines scored 356 points, ranking 79th among 81 participating countries, with scores significantly below the OECD average (485) and similar to its 2018 performance. This indicates that Filipino students remain substantially behind global peers, often by several years of learning, despite minor fluctuations in scores.

The abstract nature of science learning, especially physics, which relies heavily on mathematics as the primary language for understanding concepts, further complicates skill mastery [4−5]. Students often encounter difficulties in understanding concepts related to straight-line motion, particularly in distinguishing and identifying quantities such as speed, acceleration, distance, and displacement [6]. Likewise, Rohmah and Handhika [7] reported that misconceptions in straight-motion topics are prevalent among students. Their findings revealed misconceptions in several areas, including free-fall motion (44%), speed and acceleration (21%), vertical upward motion (32%), distance and displacement (5%), speed (32%), uniform straight-line motion (16%), and uniformly accelerated straight-line motion (39%). These results indicate that misconceptions remain a significant challenge in learning kinematics concepts. According to Kurniawan and Suhandi [8], misconceptions occur when individuals are unable to properly relate or explain phenomena in their surroundings using the concepts they possess. Misconceptions are described as understandings or ideas that are inconsistent with established scientific concepts [9]. Misconceptions may arise from various sources, including students, teachers, textbooks, learning contexts, and instructional approaches [10]. The insufficient availability of science laboratories and laboratory equipment in the Philippines continues to be a major concern, particularly in relation to the quality of science education. According to data from the University of the Philippines Diliman [11], 4,520 out of 12,390 high schools across the country lack laboratory facilities, while many existing laboratories are not equipped with modern digital technologies. This deficiency limits students' opportunities to conduct experiments and participate in hands-on learning activities, which are essential for enhancing scientific understanding and developing practical science skills. Additionally, teacher-centered approaches exacerbate the challenges of learning physics concepts. Teacher-centered instructional approaches often restrict student interaction and engagement, thereby limiting opportunities for deeper and more meaningful learning experiences [12]. In addition, studies have shown that assessment systems significantly influence how teachers design and implement their instructional practices [13]. Furthermore, international reports, such as those from the OECD [1], emphasize that the use of effective and well-structured teaching methodologies is essential in enhancing student learning outcomes. According to constructivist learning theory, students are perceived as unique individuals with varied experiences who interact with their environment and construct meaningful knowledge independently. Therefore, several strategies can be applied to shift from teacher-centered to student-centered learning approaches.

IPAS (Inquiry, Process, Activity, and Skills) is a curriculum that integrates natural and social sciences. IPAS learning develops literacy and numeracy skills as well as scientific attitudes, such as critical thinking, by allowing students to gain direct experience and practice in a meaningful and authentic way [14]. While some activity sheets exist, they are not systematically developed to align with students' local materials and experiences. Using experiment-based IPAS Exploration Sheets in General Physics 1, specifically on the topic of kinematics, provides students with concrete experiences that foster a more meaningful understanding of the concepts. Wulandari et al. [15] developed the Experiment-Based IPAS Exploration Sheet (LEPAS), which integrated simple experiments and traditional games to teach fundamental science principles. The study demonstrated that contextually grounded, interactive learning media encourage participation, enhance critical thinking, and make abstract concepts more tangible by connecting theoretical knowledge with real-world applications [16]. Self-paced learning modules have emerged as an effective strategy to address these challenges. Avenir and Bacani [17] developed a self-paced module for General Physics 2, aligned with the Department of Education's Most Essential Learning Competencies (MELCs). The module targeted least-learned competencies and was validated by experts in content, instructional design, and technical quality, receiving "very satisfactory" ratings in all areas. Integrating self-regulated learning (SRL) principles such as goal setting, reflective thinking, and learner autonomy enhanced cognitive engagement and facilitated mastery of complex physics concepts [18]. This demonstrates that well-designed modular materials can significantly improve understanding, engagement, and retention, even in remote or self-directed learning contexts.

Furthermore, teachers handling the same subject need unified materials to ensure consistent learning experiences across all strands. Thus, a gap exists in the absence of well-designed, experiment-based Exploration Sheets, particularly for the topic "Kinematics," which can make concepts more concrete, enhance process and analytical skills, and provide accessible, contextualized, inquiry-based learning materials for Grade 12 students. This study aims to develop a Unified Experiment-Based Exploration Sheet for General Physics 1, specifically focusing on kinematics. It seeks to address the difficulties students experience in understanding and applying theoretical concepts in motion, velocity, and acceleration. It is intended to make abstract concepts more concrete through guided experimentation, using simple and locally available materials to ensure accessibility in resource-limited classrooms.

## 2. Materials and Methods

### *2.1. Research design.*

This study employed a research and development (R&D) design, which involves creating new products or improving existing products and testing their effectiveness [19]. The framework of this study is based on the 4D Model of development by Thiagarajan et al. [20], which outlines four systematic phases shown in Figure 1: 1) Define, 2) Design, 3) Develop, and 4) Disseminate.

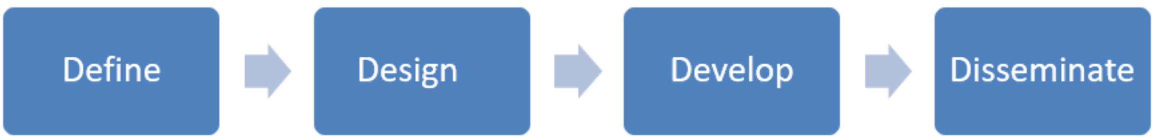


**Figure 1.** Phases of the 4D model of development.

The 4D model (Define, Design, Develop, Disseminate) is widely recognized as an appropriate instructional development framework for producing validated and classroom-ready learning materials, particularly in science education. Its structured and systematic phases ensure that instructional products are aligned with learner needs, curriculum standards, and empirical validation processes. In the Define phase, the model emphasizes needs analysis as a foundation for instructional design. This is consistent with instructional development principles that highlight the importance of diagnosing learners' difficulties and identifying curriculum gaps before material construction [20−21]. In the context of the kinematics exploration sheet, this phase was used to examine DepEd competencies in General Physics 1 and documented student misconceptions in motion concepts, ensuring that the material directly addressed identified learning difficulties [6−7].

During the Design phase, the framework supports the systematic planning of learning activities, sequencing of content, and alignment with instructional objectives. According to [22], instructional design models such as ADDIE and related frameworks emphasize the importance of aligning learning tasks with outcomes and selecting appropriate strategies to promote conceptual understanding. In this study, inquiry-based tasks, guiding questions, and structured exploration activities were designed to enhance students' understanding of kinematics concepts. In the Develop phase, the 4D model highlights iterative refinement through expert validation and revision. Thiagarajan [20] emphasize that instructional materials must undergo expert review and revision to ensure content validity and instructional quality. Similarly, Dick et al. [21] stress the importance of formative evaluation in improving the effectiveness of learning materials. Accordingly, the kinematics exploration sheet was reviewed by experts and revised based on feedback to improve accuracy, clarity, and pedagogical effectiveness.

Finally, in the Disseminate phase, the model supports implementation and evaluation in real educational settings. Research in instructional design underscores that dissemination and field testing are essential for determining usability and effectiveness in authentic classrooms [22]. In this study, the finalized exploration sheet was implemented in Grade 12 Physics classes, allowing for evaluation of its impact on student learning and engagement, consistent with best practices in educational material development. Overall, the use of the 4D model is appropriate because it provides a systematic, research-based, and iterative process for developing instructional materials that are both pedagogically sound and responsive to learner needs [20−22].

### *2.2. Sampling and participants.*

The study purposively selected four experts to validate the Exploration Sheets. These experts were composed of teachers handling General Physics 1 and master teachers with advanced knowledge of the curriculum and content, ensuring that the learning material was evaluated in terms of content accuracy, pedagogical alignment, and curriculum relevance. The use of expert validators is consistent with instructional material development studies, which emphasize expert judgment as a key source of content validity [23]. In addition, 50 STEM senior high school students from Surigao City National High School were selected as participants for the implementation of the Exploration Sheets. The sample size of 50 was considered adequate for a classroom-based quasi-experimental pretest–post-test design, as similar studies in educational interventions commonly use moderate sample sizes ranging from 30 to 60 participants to determine instructional effectiveness [24]. This number also reflects practical constraints in school-based research while still allowing meaningful statistical comparison of pre-test and post-test performance.

Stratified random sampling was used to improve representativeness and reduce sampling bias. Three STEM classes were selected, and each class was divided into eight strata based on existing classroom groupings or student distribution. From each stratum, two to three students were randomly selected, ensuring that participants were proportionally represented across sections and minimizing the risk of overrepresenting higher- or lower-performing groups. Stratified sampling is recommended in educational research because it increases sample representativeness and improves the precision of estimates compared to simple random sampling, especially when the population is heterogeneous [25]. The selected participants took a 40-item multiple-choice questionnaire as both pre-test and post-test. Their scores were compared and analyzed to determine the effectiveness of the Exploration Sheets in improving students' conceptual understanding of kinematics.

*2.3 Research instrument.*

The research instrument was developed using the 4D model (Define, Design, Develop, Disseminate), a systematic instructional development framework commonly used in educational material design [20, 22]. In the Define phase, the researcher conducted a needs analysis involving the Most Essential Learning Competencies (MELCs) for Kinematics in General Physics 1, material analysis, and learner analysis to identify common misconceptions and learning difficulties in motion concepts. This process ensured that the developed Exploration Sheet was aligned with curriculum requirements and addressed students identified learning gaps [21].

In the Design phase, the structure and content of the Exploration Sheet were planned. Learning activities were designed to promote conceptual understanding of key kinematics topics such as distance, displacement, speed, velocity, acceleration, uniform motion, uniformly accelerated motion, and free-fall motion. Inquiry-based tasks, guiding questions, and experimental procedures were incorporated to encourage active learning and scientific reasoning. According to instructional design principles, this phase ensures alignment between learning objectives, instructional strategies, and assessment tasks [22].

In the Develop phase, the initial prototype of the Exploration Sheet was produced and refined based on expert validation and feedback. Four experts in General Physics 1 evaluated the material in terms of content accuracy, instructional quality, and alignment with learning competencies. Expert validation is a widely accepted procedure in educational research to establish content validity and improve instructional quality before implementation [23]. Revisions were made based on their comments to enhance clarity, accuracy, and pedagogical effectiveness.

In the Disseminate phase, the finalized Exploration Sheet was implemented among student participants and evaluated for effectiveness in improving learning outcomes. The evaluation also included qualitative feedback from implementation to determine usability and acceptability in a classroom setting. Dissemination and field testing are essential components of instructional development models to ensure that materials are functional and effective in real educational environments [22].

To measure student learning outcomes, a standardized 40-item multiple-choice test was developed and administered as both a pre-test and post-test. The test covered the core competencies in kinematics, including conceptual understanding and problem-solving in distance, displacement, speed, velocity, acceleration, and motion under uniform and uniformly accelerated conditions. Each item was aligned with the MELCs and categorized according to cognitive levels such as remembering, understanding, and applying. The test underwent expert validation for content relevance, clarity, and difficulty level to ensure its validity and reliability before administration [26]. Additionally, item construction followed standardized test development procedures to ensure fairness, consistency, and measurement accuracy in assessing students' conceptual understanding [27].

*2.4. Data collection and data analysis.*

The data for this study were collected systematically to evaluate the development and effectiveness of the Unified Experiment-Based Exploration Sheet for Grade 12 General Physics 1, specifically on the topic of Kinematics. First, fifty (50) Grade 12 STEM students from Surigao City National High School were randomly selected as participants, while four experts composed of General Physics 1 teachers and master teachers qualitatively validated the Exploration Sheet through structured comments and feedback focusing on its content quality, instructional quality, technical quality, and other relevant aspects. Expert validation is commonly used in instructional material development to establish content validity and ensure pedagogical appropriateness prior to implementation [23].

Prior to the implementation of the Exploration Sheet, a standardized 40-item multiple-choice test on kinematics concepts was administered to assess students' baseline knowledge, and the results served as the pre-test data. The students then completed the Experiment-Based Exploration Sheet, which included guided experiments and reflection activities designed to enhance conceptual understanding. After completing the activities, the same 40-item test was administered as a post-test to determine learning gains, and the scores were recorded for analysis.

The collected data were analyzed to determine the validity and effectiveness of the developed Exploration Sheet. Expert validation feedback was summarized to identify key observations regarding content quality, instructional quality, technical quality, and other relevant aspects. Descriptive statistics, particularly the mean and percentage, were used to summarize and interpret students' pre-test and post-test performance, as these are commonly used in educational research to describe central tendency and learning outcomes [23]. To determine whether there was a significant difference between pre-test and post-test scores, a paired-sample t-test was applied, which is appropriate for comparing two related groups in pretest–post-test research designs [28].

## 3. Results and Discussion

The Exploration Sheet was evaluated by four experts, including General Physics 1 teachers and master teachers. Overall, the experts found the material to be relevant, practical, and aligned with the Most Essential Learning Competencies (MELCs), particularly in introducing uniformly accelerated motion through a hands-on ramp experiment. The activity was considered appropriate for developing students' skills in measuring time, analyzing motion, and computing acceleration. However, the experts also identified several areas for improvement.

While the material demonstrated strong alignment with competencies related to constant acceleration and kinematic equations, its alignment with graphical interpretation skills (e.g., velocity–time and acceleration–time graphs) was only partial. Consequently, revisions were recommended to improve clarity, usability, and learner support. These revisions included the addition of structured data tables, clearer formatting, safety reminders, and step-by-step computation guides. Table 1 presents a summary of the expert validation findings and the corresponding revisions made to the Exploration Sheet.

**Table 1.** Summary of expert validation findings and revisions.

| Domain | Expert Observation | Revision Implemented |
|---|---|---|
| Content | Strong alignment with MELCs | Added a graphing extension activity to strengthen graphical interpretation skills |
| Instructional Quality | Learning objectives were clear but required additional scaffolding | Added a step-by-step computation guide |
| Technical Quality | Formatting and organization needed improvement | Enhanced layout, section headings, and visual organization |
| Usability | Lack of structured data recording tools | Added structured data tables for observations and computations |
| Safety | Safety precautions were not explicitly stated | Included safety reminders and laboratory precautions |

These findings are consistent with instructional design literature, which emphasizes expert validation as an essential process for enhancing content validity and instructional quality prior to classroom implementation [23]. To establish students' baseline understanding of kinematics concepts, a pre-test was administered before the implementation of the Exploration Sheet. The descriptive statistics of the pre-test scores are presented in Table 2.

**Table 2.** Pre-test performance of students (N = 50).

| Statistic | Value |
|---|---|
| Mean | 28.6 |
| Median | 30.0 |
| Standard Deviation | 5.37 |
| Minimum | 18 |
| Maximum | 40 |

The pre-test results presented in Table 2 indicate that students had a relatively low initial understanding of kinematics concepts. The mean score of 28.6 (SD = 5.37) suggests limited prior knowledge of concepts such as displacement, velocity, and acceleration. The relatively large standard deviation indicates considerable variation in students' prior knowledge. This finding suggests that learners entered the class with differing levels of conceptual understanding, possibly resulting from variations in previous learning experiences, exposure to physics concepts, and existing misconceptions [29]. Following the implementation of the Exploration Sheet, a post-test was administered to assess students' learning gains. Table 3 summarizes the descriptive statistics of the post-test scores.

**Table 3.** Post-test performance of students (N = 50).

| Statistic | Value |
|---|---|
| Mean | 37.3 |
| Median | 40.0 |
| Standard Deviation | 4.64 |
| Minimum | 25 |
| Maximum | 40 |

As shown in Table 3, students' performance improved substantially after the implementation of the Exploration Sheet. The mean post-test score increased to 37.3 (SD = 4.64), indicating a considerable improvement in students' understanding of kinematics concepts. Furthermore, the decrease in standard deviation from 5.37 to 4.64 suggests a reduction in performance variability, indicating that students achieved a more consistent level of understanding following the intervention. The reduced standard deviation suggests more consistent performance among learners after the intervention (Figure 2). This indicates that the Exploration Sheet helped standardize understanding by providing structured inquiry-based learning experiences [30].

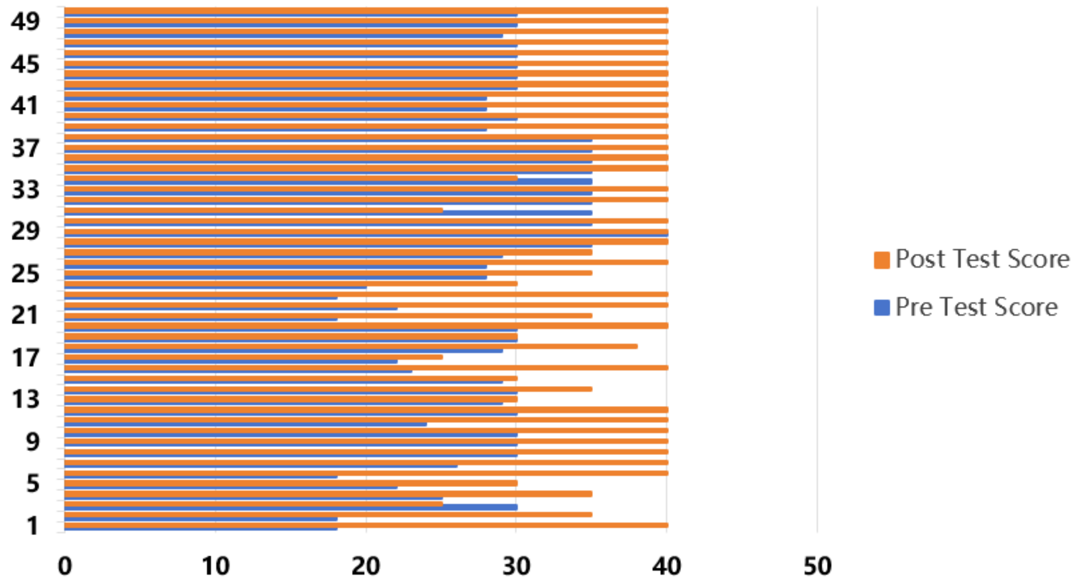

**Figure 2.** Comparison of pre-test and post-test scores.

The students obtained a mean gain score of 8.68 (SD = 6.61) as shown in Table 4, indicating an overall improvement in their learning outcomes after the implementation of the intervention. However, the relatively high standard deviation suggests considerable variability in students' responses to the Exploration Sheet, meaning that while some learners demonstrated substantial improvement, others showed only minimal progress (Figure 3). This variation may be explained by differences in student engagement, prior misconceptions in kinematics concepts, and their ability to adapt to inquiry-based learning strategies. In terms of normalized gain analysis [31], most students achieved medium gains (0.3–0.7), while a smaller proportion attained high gains (≥ 0.7), and only a few recorded low or negative gains (< 0.3). The presence of zero and negative gains may be attributed to persistent conceptual misunderstandings, possible absenteeism during the intervention, or challenges in adjusting to active and student-centered learning approaches, as similarly observed in previous physics education studies [32].

**Table 4.** Learning gain result.

| | Gains |
|---|---|
| N | 50 |
| Mean | 8.68 |
| Median | 10.0 |
| Standard deviation | 6.61 |
| Minimum | -10 |
| Maximum | 22 |

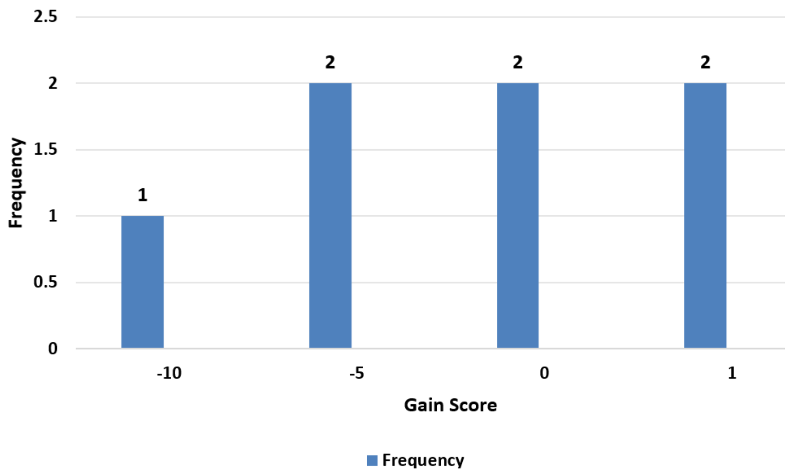


**Figure 3.** Distribution of gain score.

A paired-samples t-test was also conducted to determine whether the difference between the pre-test and post-test scores was statistically significant. The results revealed a highly significant difference between the two sets of scores ($p < .001$) shown in Table 5. The computed effect size (Cohen's $d = 1.31$) indicates a large effect, suggesting strong practical significance of the intervention [33]. The estimated percentage improvement was approximately 30.4%, demonstrating meaningful learning gains. This indicates that the improvement observed after the implementation of the unified experimental sheets was not due to chance. The hands-on ramp experiment significantly contributed to students' understanding of uniformly accelerated motion. By directly measuring time intervals and calculating acceleration, students were able to connect theoretical equations with real-world motion. This aligns with constructivist learning theory, which emphasizes that learners construct knowledge through active engagement and experience [34]. The activity also supported conceptual change by confronting students' misconceptions about constant acceleration and velocity relationships.

**Table 5.** Paired-samples t-test comparing pre-test and post-test scores.

| Comparison | t | df | p |
|---|---|---|---|
| Pre-Test vs. Post-Test | -9.29 | 49 | < .001 |

**Note.** Paired-samples t-test. $H_a$: μPre-Test − μPost-Test ≠ 0.

*3.1. Limitations.*

This study focuses on the development and validation of a Unified Experiment-Based Exploration Sheet specifically designed for the Kinematics lesson in General Physics 1 for Grade 12 students. The material is developed and intended to support inquiry-based and hands-on learning using simple, low-cost, and locally available materials, making it suitable for schools with limited laboratory facilities. This study is limited to develop exploration sheets on the topic of Kinematics, other topics in General Physics 1 are not part of the development. The pilot testing is limited to the Grade 12 students of Surigao City National High School of school year 2025-2026. Results may vary if administered to other schools with different learner profiles or instructional contexts. Student performance may be influenced by factors beyond the control of the research, such as prior knowledge in mathematics, study habits, or differences in teacher facilitation during the implementation.

## 4. Conclusions

This study demonstrated that the Unified Experiment-Based Exploration Sheet is an effective instructional material for improving Grade 12 students' understanding of kinematics in General Physics 1. The findings revealed a substantial improvement in students' academic performance, with the mean score increasing from 28.6 in the pre-test to 37.3 in the post-test, resulting in a mean gain score of 8.68. The paired-samples t-test further confirmed a statistically significant difference between the pre-test and post-test scores, $t$ (49) = -9.29, $p < .001$, indicating that the observed improvement was attributable to the intervention rather than chance. The large effect size likewise demonstrated the practical significance of the Exploration Sheet in enhancing students' conceptual understanding of kinematics. The results suggest that structured, standardized, and inquiry-based learning activities can effectively support the learning of abstract physics concepts. Through hands-on experimentation and guided exploration, students were able to actively engage with concepts of velocity, acceleration, and uniformly accelerated motion, thereby fostering deeper conceptual understanding and scientific inquiry skills. Moreover, the use of low-cost and readily available materials highlights the practicality and accessibility of the Exploration Sheet, particularly in resource-limited educational settings. Overall, the Unified Experiment-Based Exploration Sheet represents a viable and sustainable approach to enhancing physics instruction and promoting meaningful learning experiences. Its successful implementation demonstrates the potential of experiment-based instructional materials to improve student learning outcomes while encouraging active participation in the scientific process. Future studies may examine the effectiveness of the Exploration Sheet in other physics topics, such as dynamics, work and energy, momentum, and electricity. Research involving larger sample sizes, multiple schools, and diverse educational contexts is also recommended to enhance the generalizability of the findings. Additionally, future investigations may explore the long-term effects of the Exploration Sheet on students' retention of concepts, scientific reasoning abilities, and attitudes toward physics learning.

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### Author Contribution

Dyvie Calunsag Flores conceptualized the study, conducted the literature review, designed the research methodology, collected and analyzed the data, interpreted the results, and prepared the manuscript. Mauricio S. Adlaon provided supervision, guidance, and scholarly feedback throughout the research process and critically reviewed the manuscript for intellectual content. All authors have read and approved the final version of the manuscript.

## Competing Interest

The authors declare that they have no competing interests. There are no financial, personal, or professional relationships that could have influenced the conduct of this study or the interpretation of its findings.

## Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

## References


[1] Organisation for Economic Co-operation and Development (OECD). (2023). PISA 2022 results: Factsheets – Philippines. (accessed on 1 March 2026) Available online: https://www.oecd.org/content/dam/oecd/en/publications/reports/2023/11/pisa-2022-results-volume-i-and-ii-country-notes_2fca04b9/philippines_dbf92b65/a0882a2d-en.pdf.

[2] Limon, M.R. (2016). The effect of the adequacy of school facilities on students' performance and achievement in technology and livelihood education. *International Journal of Academic Research in Progressive Education and Development*, *5*(1), 47−59. https://doi.org/10.6007/IJARPED/v5-i1/2060.

[3] Reyes, R.; Pacala, F.A.A.; Bengua, G.; Entac, E. (2024). The correlation between students' insights and academic achievement in science: A predictor for STEM career path. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, *14*(1), 1−18. https://doi.org/10.30998/formatif.v14i1.17616.

[4] Örnek, F.; Robinson, W.R.; Haugan, M.P. (2008). What makes physics difficult? *International Journal of Environmental and Science Education*, *3*(1), 30–34.

[5] Pullicino, N.; Bonello, C. (2020). Challenges Faced by Maltese Students Studying Advanced Level Physics. *Information*, *11*, 397. https://doi.org/10.3390/info11080397.

[6] Martini, B.; Michelini, M.; Stefanel, A.; Tombolato, M. (2021). Prospective Teachers' Representations on the Concept of Force. *Education Sciences*, *11*, 614. https://doi.org/10.3390/educsci11100614.

[7] Ma, H.; Yang, H.; Li, C.; Ma, S.; Li, G. (2025). The Effectiveness and Sustainability of Tier Diagnostic Technologies for Misconception Detection in Science Education: A Systematic Review. *Sustainability*, *17*, 3145. https://doi.org/10.3390/su17073145.

[8] Siddiqui, S. (2022). Categorized and Correlated Multiple-Choice Questions: A Tool for Assessing Comprehensive Physics Knowledge of Students. *Education Sciences*, *12*, 575. https://doi.org/10.3390/educsci12090575.

[9] Kariotoglou, P.; Psillos, D. (2019). Teaching and Learning Pressure and Fluids. *Fluids*, *4*, 194. https://doi.org/10.3390/fluids4040194.

[10] Suparno, P. (2013). Miskonsepsi dan perubahan konsep dalam pendidikan fisika; Grasindo: Jakarta, Indonesia.

[11] SCIENCE - University of the Philippines Diliman. (accessed on 1 March 2026) Available online: https://science.upd.edu.ph/

[12] Bransford, J.D.; Brown, A.L.; Cocking, R.R. (2000). How people learn: Brain, mind, experience, and school; National Academy Press: Washington, DC, USA.

[13] Black, P.; Wiliam, D. (2009). Developing the theory of formative assessment. *Educational Assessment, Evaluation and Accountability*, *21*(1), 5–31. https://doi.org/10.1007/s11092-008-9068-5.

[14] Paucar-Curasma, R.; Sapallanay-Gomez, N.N.; Cayllahua Yarasca, U.; Acra-Despradel, C.; Ponce-Aranibar, M.d.P. (2026). Enhancing Research Competencies in University Students

Through a Polya-Based STEM Technology Integration Method. *Education Sciences*, *16*, 929. https://doi.org/10.3390/educsci16060929.
[15] Wulandari, D.T.; Sayekti, I.C. (2022). Analisis kebutuhan pengembangan media kartu pada materi ekosistem berbasis QR-code untuk siswa sekolah dasar. *Jurnal Basicedu*, *6*(4), 6428–6436. https://doi.org/10.31004/basicedu.v6i4.3258.
[16] Studhalter, U.T.; Leuchter, M.; Tettenborn, A.; Elmer, A.; Edelsbrunner, P.A.; Saalbach, H. (2021). Early science learning: The effects of teacher talk. *Learning and Instruction*, *71*, 101371. https://doi.org/10.1016/j.learninstruc.2020.101371.
[17] Avenir, F.A.; Bacani, B.B. (2025). Evaluation of developed learning module in General Physics 2 as a self-paced distance learning material. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, *15*(1). https://doi.org/10.30998/formatif.v15i1.26093.
[18] Pansri, B.; Thongchotchat, V.; Kurashige, K.; et al. (2025). Self-regulated learning in action: Empowering physics curriculum with ICT and practical approaches. *Technology, Knowledge and Learning*. https://doi.org/10.1007/s10758-025-09854-6.
[19] Salsabila, B.S.; Kartijono, N.E. (2023). The development of e-leaflet teaching materials using QR-code in human excretory system material. *Journal of Biology Education*, *12*(2), 240–247.
[20] Aguilar-Moya, R.; Diamanti, R.; Melero-Fuentes, D. (2025). Teaching Methods, Learning and Development: A 15-Year Research Perspective by Educational Stages. *Education Sciences*, *15*, 1213. https://doi.org/10.3390/educsci1509121.
[21] Dick, W.; Carey, L.; Carey, J.O. (2015). The systematic design of instruction, 8th ed.; Pearson: Boston, MA, USA.
[22] Branch, R.M. (2009). Instructional design: The ADDIE approach; Springer: New York, NY, USA. https://doi.org/10.1007/978-0-387-09506-6.
[23] DeVellis, R.F. (2017). Scale development: Theory and applications, 4th ed.; SAGE: Thousand Oaks, CA, USA.
[24] Creswell, J.W. (2012). Educational research: Planning, conducting, and evaluating quantitative and qualitative research, 4th ed.; Pearson: Boston, MA, USA.
[25] Sharma, G. (2017). Pros and cons of different sampling techniques. *International Journal of Applied Research*, *3*, 749–752.
[26] Haladyna, T.M.; Rodriguez, M.C. (2013). Developing and validating test items; Routledge: New York, NY, USA. https://doi.org/10.4324/9780203850381.
[27] Brookhart, S.M. (2024). Educational assessment knowledge and skills for teachers revisited. *Education Sciences*, *14*(7), 751. https://doi.org/10.3390/educsci14070751.
[28] Pallant, J. (2026). SPSS survival manual: A step-by-step guide to data analysis using IBM SPSS, 10th ed.; Routledge: London, UK. https://doi.org/10.4324/9781003651147.
[29] Fraenkel, J.R.; Wallen, N.E.; Hyun, H.H. (2011). How to design and evaluate research in education; McGraw-Hill: New York, NY, USA.
[30] Moemeke, C.D.; Chukwunenye, J.N.; Malik, N.A. (2025). Understanding the theoretical foundations of inquiry-based learning: Pivot for productive science education in Africa. *Educational Considerations*, *50*(3). https://doi.org/10.4148/0146-9282.2446.
[31] Ballesta-Claver, J.; Ayllón Blanco, M.F.; Gómez Pérez, I.A. (2021). A Revisited Conceptual Change in Mathematical-Physics Education from a Neurodidactic Approach: A Pendulum Inquiry. *Mathematics*, *9*, 1755. https://doi.org/10.3390/math9151755.
[32] Santoso, P.H.; Istiyono, E.; Haryanto; Hidayatulloh, W. (2022). Thematic analysis of Indonesian physics education research literature using machine learning. *Data*, *7*(11), 147. https://doi.org/10.3390/data7110147.
[33] Cohen, J. (1988). Statistical power analysis for the behavioral sciences, 2nd ed.; Lawrence Erlbaum Associates: Hillsdale, NJ, USA.

[34] Chand, S.P. (2023). Constructivism in education: Exploring the contributions of Piaget, Vygotsky, and Bruner. *International Journal of Science and Research*, *12*(7), 274–278. https://doi.org/10.21275/sr23630021800.